

# **SOUTH DELTA FISH FACILITIES**

## ***ISSUES***

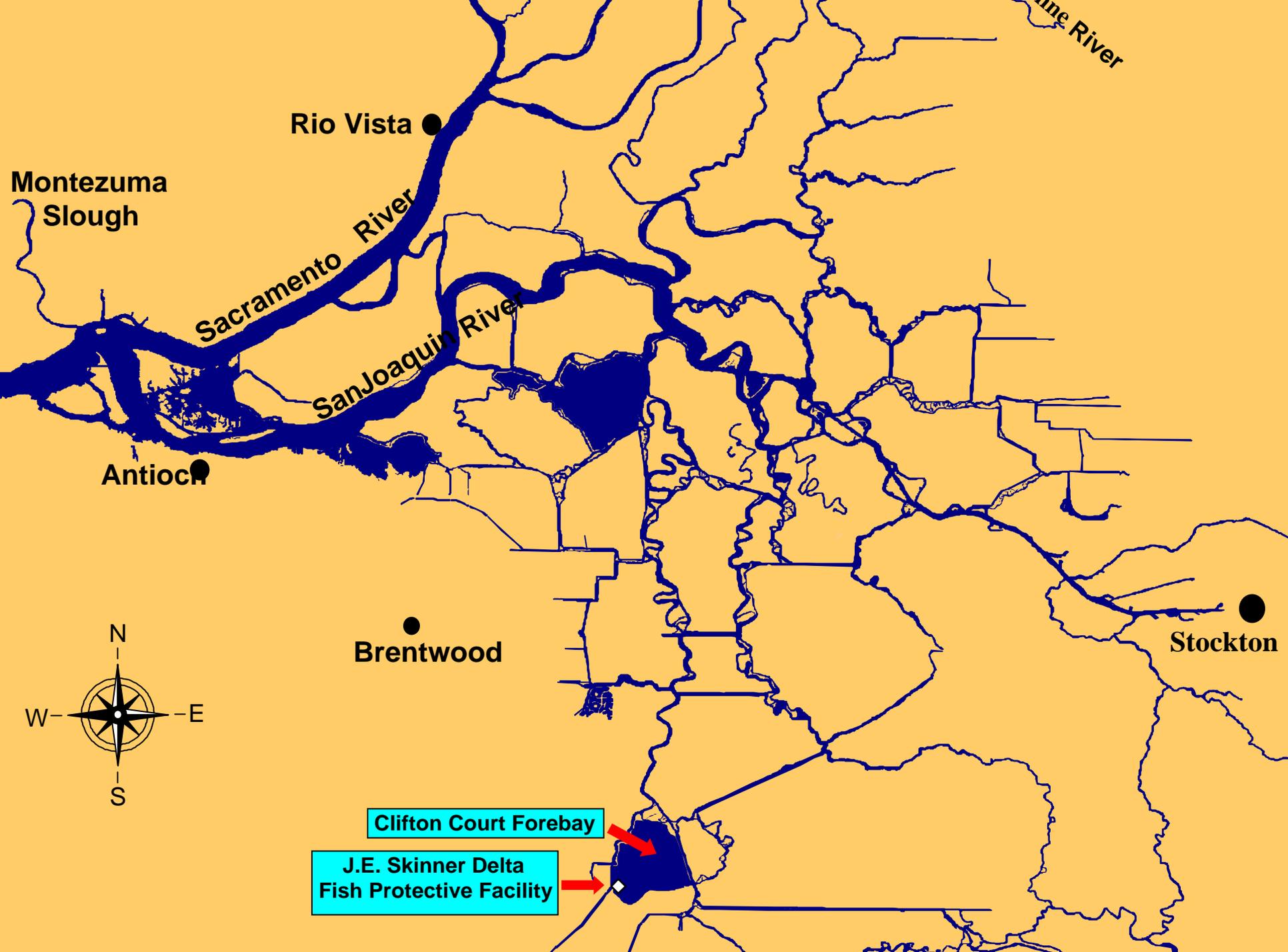
### **PREDATION IN CLIFTON**

### **COURT FOREBAY**

**J. W. Buell, Ph.D.**

**Central Valley Fish Facilities Review Team**

**April 2003**



Rio Vista ●

Montezuma Slough

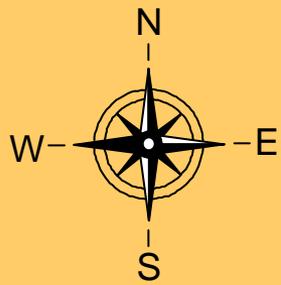
Sacramento River

San Joaquin River

Antioch ●

Brentwood ●

Stockton ●



Clifton Court Forebay

J.E. Skinner Delta Fish Protective Facility

# SOUTH DELTA FISH FACILITIES

## Perspective - Issues

- **Collect, Handle, Transport, Release (CHTR)**
- **Salvage**
- **Predation in Clifton Court Forebay**
- **South Delta Barriers**
- **Hydrodynamics**
- **Zone of Influence**
- **Population-Level Effects**
- **Other S.D. Matters (Tracy, Los Vaqueros, etc.)**

# There's a Problem . . .



# Key Points

- **CCF salmon predation losses**
  - **Eight studies during 1976 -1993**
  - **Median > 85%**
  - **Range 63 to 99+%**
- **CCF striped bass predation losses**
  - **Two studies**
  - **Range 74 to 90%**
- **After CCFB, predation loss**
  - **10 to 90% at Skinner**

# Presentation Coverage

- **Description / Importance of losses**
- **Assumptions**
- **What we know / summaries of studies**
- **Potential study biases**
- **Additional complementary studies**

# Importance of Predation in CCFB

- **“Take” starts at the Radial Gates**
- **Current assumptions drive:**
  - **“Take” calculations**
  - **Operations**
- **Overshadows “facilities” losses**
- **Solution essential to SD fish protection**

**Banks Pumps**



**Skinner Fish Facility**



**Tracy Pumps**



**Outlet Channel**



**Tracy  
Fish  
Facility**



**Radial Gates**





**Outlet  
Channel**

**Clifton  
Court  
Forebay**

**Skinner  
Fish Salvage  
Facility  
(Holding Tanks Inside)**

**Trash Boom**

**Trash Rack**

**Louvers**

**Secondary Screens/Louvers**



# Current Assumptions

(From 4-Pumps Negotiations)

- **Predation = 75% of juvenile fish entering**
  - **Based on juvenile salmon experiments**
  - **Mean of first three tests (with RG + TB releases )**
  - **However, mean of all tests > 85%**
- **No changes with temperature**
  - **However, temperature appears to be a factor**
- **No changes with pumping rate**
  - **However, losses vary inversely with pumping rate**
- **Predation is comparable for other species**
  - **However, data for striped bass and salmon only**

# SWP Losses - Chinook

## App. A, CDFG Operating Agreement, CCF Salvage Ops.

- **Expand 10-minute count ( $C_{\text{EXP}}$ ) *e.g.* = 100**
- **Correct for louver efficiency ( $E_L$ )**
  - $E_L = 0.586 + 0.0579 * \text{Vel.}$
  - For Vel. = 3.0 fps,  $E_L = 0.742$
  - Fish encountering screens:  $C_{\text{EXP}} / E_L = \underline{135}$
- **Correct for Pre-Screen Losses (CCFB predation)**
  - Ent. =  $C_{\text{EXP}} / (1 - 0.75) E_L = \underline{539}$
- **Correct for Handling, Trucking Loss ( $L_H$ ;  $L_T$ )**
  - Alive =  $C_{\text{EXP}} (1 - L_H) (1 - L_T) = \underline{96}$
- **System Loss ( $L_{\text{SYS}}$ )**
  - $L_{\text{SYS}} = \text{Ent.} - \text{Alive} = \underline{441}$ ; System Survival = 17.8%

# CVP Losses - Chinook

## NMFS Biological Opinion (1993)

- **Expand 10-minute count ( $C_{\text{EXP}}$ ) e.g. = 100**
- **Correct for louver efficiency ( $E_L$ )**
  - $E_L = 0.586 + 0.0579 * \text{Vel.}$
  - For Vel. = 3.0 fps,  $E_L = 0.742$
  - Fish encountering screens:  $C_{\text{EXP}} / E_L = \underline{135}$
- **Correct for Assumed Pre-Screen Losses**
  - Ent. =  $C_{\text{EXP}} / (1 - 0.15) E_L = \underline{142}$
- **Correct for Handling, Trucking Loss ( $L_H$ ;  $L_T$ )**
  - Alive =  $C_{\text{EXP}} (1 - L_H) (1 - L_T) = \underline{96}$
- **System Loss ( $L_{\text{SYS}}$ )**
  - $L_{\text{SYS}} = \text{Ent.} - \text{Alive} = \underline{43}$ ; System Survival = 67.6%

# What We Know...

## Current Information Base

- **Ten studies (1976 - 1993); See Gingras 1997**
- **Various conditions**
  - Pumping rates
  - Seasons
  - Temperatures
  - Release points
- **Additional complimentary studies**
  - Predator population, census
  - Predator ingress - egress
  - Predator tracking
  - Creel census
  - Predator removal efforts

# What We Know (cont.)

- **CCFB pre-Skinner salmon losses (8 studies)**
  - All but one used RG + TB releases, multiple releases / times
  - Range = 63 - 99+%; average > 85%
  - Proportional to residence time (fish and water)
  - Generally, about 2 days to cross CCFB
  - Smaller fish lost selectively over time
  - Higher for day releases (RG and TB releases)
  - Overall loss coefficient of variation, 8 studies = 15%
- **CCFB pre-Skinner striped bass losses (2 studies)**
  - RG + TB releases, multiple releases / times
  - Range = 70 - 94%
  - Apparently related to residence time
  - Much higher for day releases (controls)

# Study, Analysis, Report Review by Fish Facilities Consulting Board Peripheral Canal Effort

- **Dr. Loren Jensen (Johns Hopkins Univ.)**
- **Dr. James Harder (U.C. Berkeley)**
- **Dr. Ernie Salo (Univ. of Washington)**
- **Mr. Milo Bell (Univ. of Washington)**
- **Mr. Chuck Wagner (NMFS; Chief, Fish. Eng.)**
- **Mr. Don Kelly (CDFG, Ret.)**

# Study Results (chinook) . . .

- **Mid-October 1976 (fall chinook)**
  - Releases @ radial gates; no TB releases; off peak pumping
  - 97% “unaccounted loss”
  - Selective loss of smaller fish
- **Late October 1978 (late fall chinook)**
  - Releases @ radial gates + outlet channel; trash boom
  - 86% CCFB loss (to trash boom)
  - 49% Outlet channel loss (to trash boom)
  - Selective loss of smaller fish over time ( $r^2=0.86-0.93$ )
- **Late April 1984 (fall chinook)**
  - Releases @ radial gates; trash boom
  - 63% CCFB loss (to trash boom)
  - 75% Radial gate to salvage loss



RADIAL  
GATES

Model for Fish Loss; Spring, 1984 Data

(Fall chinook; 60 - 100 mm FL)

100 FISH

TRASH  
BOOM

37 FISH

LOUVERS

33 FISH

HOLDING  
TANKS

24 FISH



MIRRORS PRESENT ASSUMPTIONS  
NEAR-BEST CASE

# Study Results (chinook) . . .

- **Early April 1985 (fall chinook)**
  - Releases @ radial gates; day + night @ trash boom
  - 75% CCFB losses (to trash boom)
  - 46 - 52% Trash boom losses (to louvers)
  - Survival proportional to pumping rate
- **Early May 1992 (fall chinook)**
  - Releases @ radial gates; night @ trash boom
  - Pumping: 6400 ~~↙~~ 375 ~~↙~~ 0 cfs 13 hrs after release
  - 99% CCFB loss (to trash boom); 71% TB to louver loss
- **Early April 1993 (fall chinook)**
  - Releases @ radial gates; day + night @ trash boom
  - 95% CCFB losses (to trash boom)
  - 75% Trash boom to louver loss (higher night survival)

# Study Results (chinook)

- **Mid-December 1992 (late fall chinook)**
  - Releases @ radial gates; night @ trash boom
  - 78% CCFB losses (to trash boom)
  - Selective loss of smaller fish
- **Late November 1993 (late fall chinook)**
  - Releases @ radial gates: afternoon + acclimated + night
  - Releases @ trash boom: morning + afternoon + night
  - 99.8% CCFB loss (to trash boom) for day release
  - 98.6% CCFB loss (to trash boom) for night release
  - 68% Trash boom to louver loss for morning release
  - 69% Trash boom to louver loss for afternoon release
  - 53% Trash boom to louver loss for night release

# Study Results (striped bass)

- **Mid-July 1984 (striped bass)**
  - Releases @ radial gates; day + night @ trash boom
  - 94% CCFB loss (to trash boom)
  - 64% Trash boom to louver loss
- **Early August 1986 (striped bass)**
  - Releases @ radial gates; day + night @ trash boom
  - 70% CCFB losses (to trash boom)
  - 60 - 90% Trash boom to louver loss, night v. day

# SUMMARY-- CCFB PREDATION LOSSES

<u>Mo-Year</u>	<u>Fish</u>	<u>RG =&gt; TB</u>
Oct-76	Fall ch.	<u>90%</u> ±
Oct-78 *	Late fall ch.	<u>86%</u>
Apr-84 *	Fall ch.	<u>63%</u>
Apr-85 *	Fall ch.	<u>75%</u>
May-92	Fall ch.	<u>99%</u>
Dec-92	Late fall ch.	<u>78%</u>
Apr-93	Fall ch.	<u>95%</u>
Nov-93 **	Late fall ch.	<u>99+%</u>
Jul-84	Striped bass	<u>94%</u>
Aug-86	Strriped bass	<u>70%</u>

# SUMMARY-- SWP PREDATION LOSSES

<u>YEAR</u>	<u>Fish</u>	<u>RG =&gt; TB</u>	<u>TB =&gt; Lv</u>	<u>RG =&gt; Lv</u>
Oct-76	Fall ch.	--	--	<u>97%</u>
Oct-78	L. fall ch.	86%	15%	<u>88%</u>
Apr-84	Fall ch.	63%	9.8%	<u>76%</u>
Apr-85	Fall ch.	75%	48%	<u>87%</u>
May-92	Fall ch.	99%	71%	<u>99+%</u>
Dec-92	L. fall ch.	78%	25%	<u>84%</u>
Apr-93	Fall ch.	95%	75%	<u>99%</u>
Nov-93	L. fall ch.	99+%	69%	<u>99+%</u>
Jul-84	Str. bass	94%	64%	<u>98%</u>
Aug-86	Str.bass	70%	60-90%	<u>78%</u>

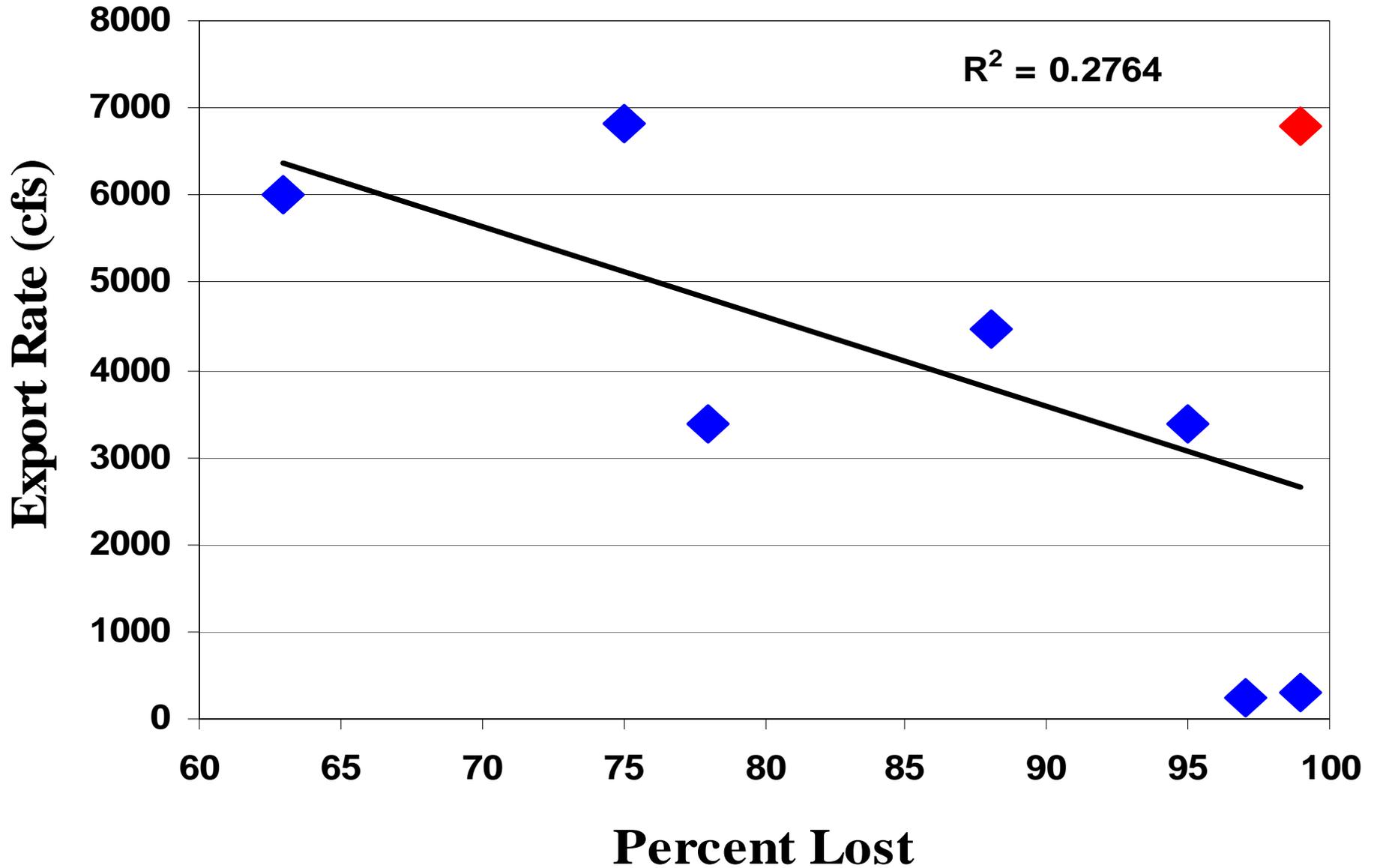
# CCFB Losses v. Export Rate

## Gingras 1997:

- **Multiple regression:**
  - Temperature
  - Released fish size
  - Export rate
- **NS; P = 0.491**
- **Omit winter 1993: P = 0.04; expl. 91% of  $s^2$** 
  - Different release methods
  - Several small release groups at Radial Gates
- **Strongest variable = Export Rate**
  - Multiple  $r^2 = 0.75...$  “Not surprising”
  - Related to prey residence time in CCFB (4 citations)

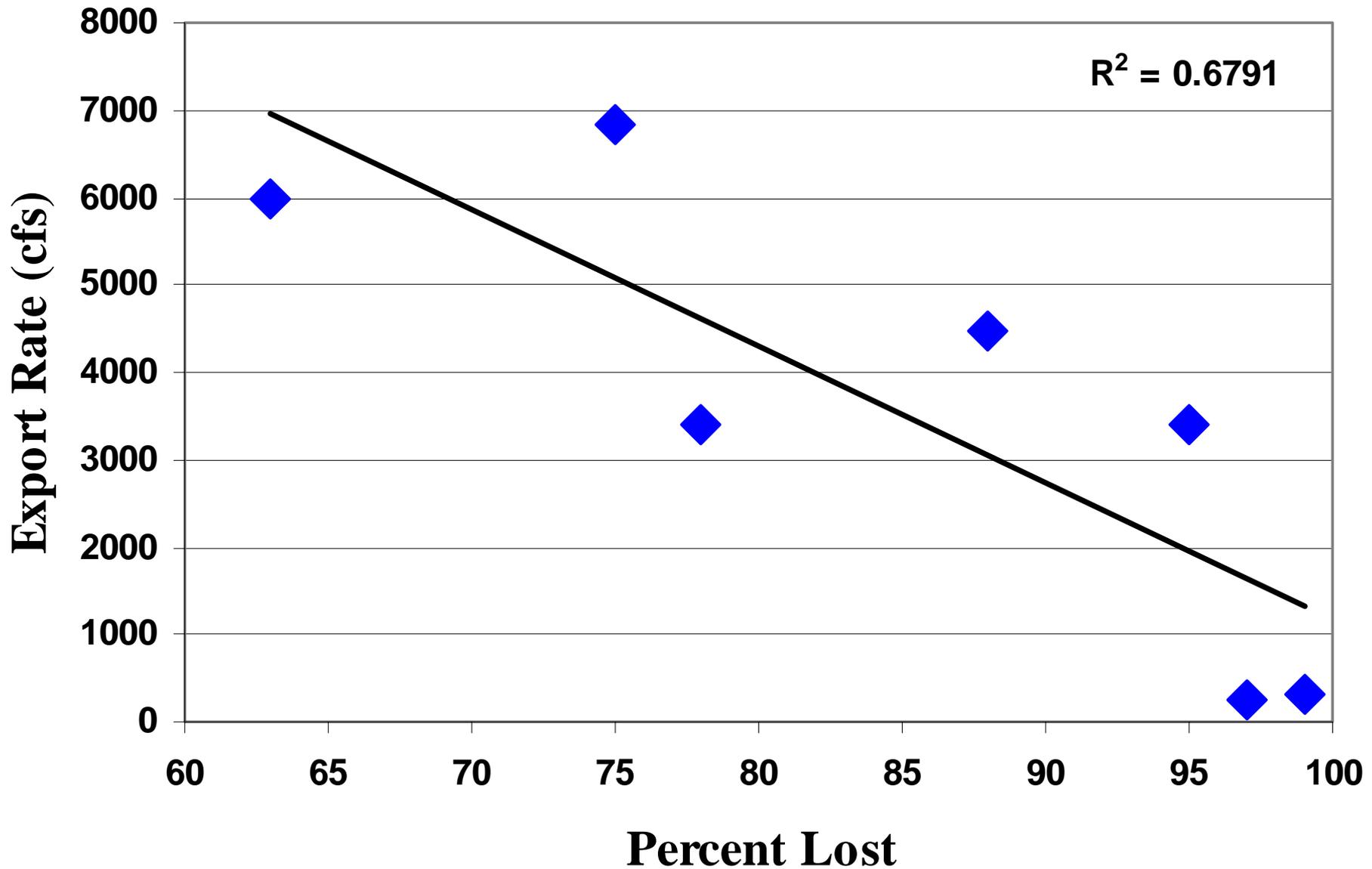
# CCFB Pre-Screen Losses -- Salmon

Percent Loss v. Export Rate



# CCFB Pre-Screen Losses -- Salmon

## Percent Loss v. Export Rate



# POTENTIAL SIGNIFICANT BIASES

Tending to under estimate predation:

- Assumed lower efficiencies (low)
- Density-dependent predator avoidance

Tending to over estimate predation:

- Disorientation at release
- Density-dependent lower efficiency
- Poor swimming of test fish
- Poor test fish predator avoidance

Other

- Mark shedding (<5%)
- Emigration from CCFB (very unlikely)
- Residence in CCFB (data suggest otherwise)

# ADDITIONAL COMPLEMENTARY STUDIES

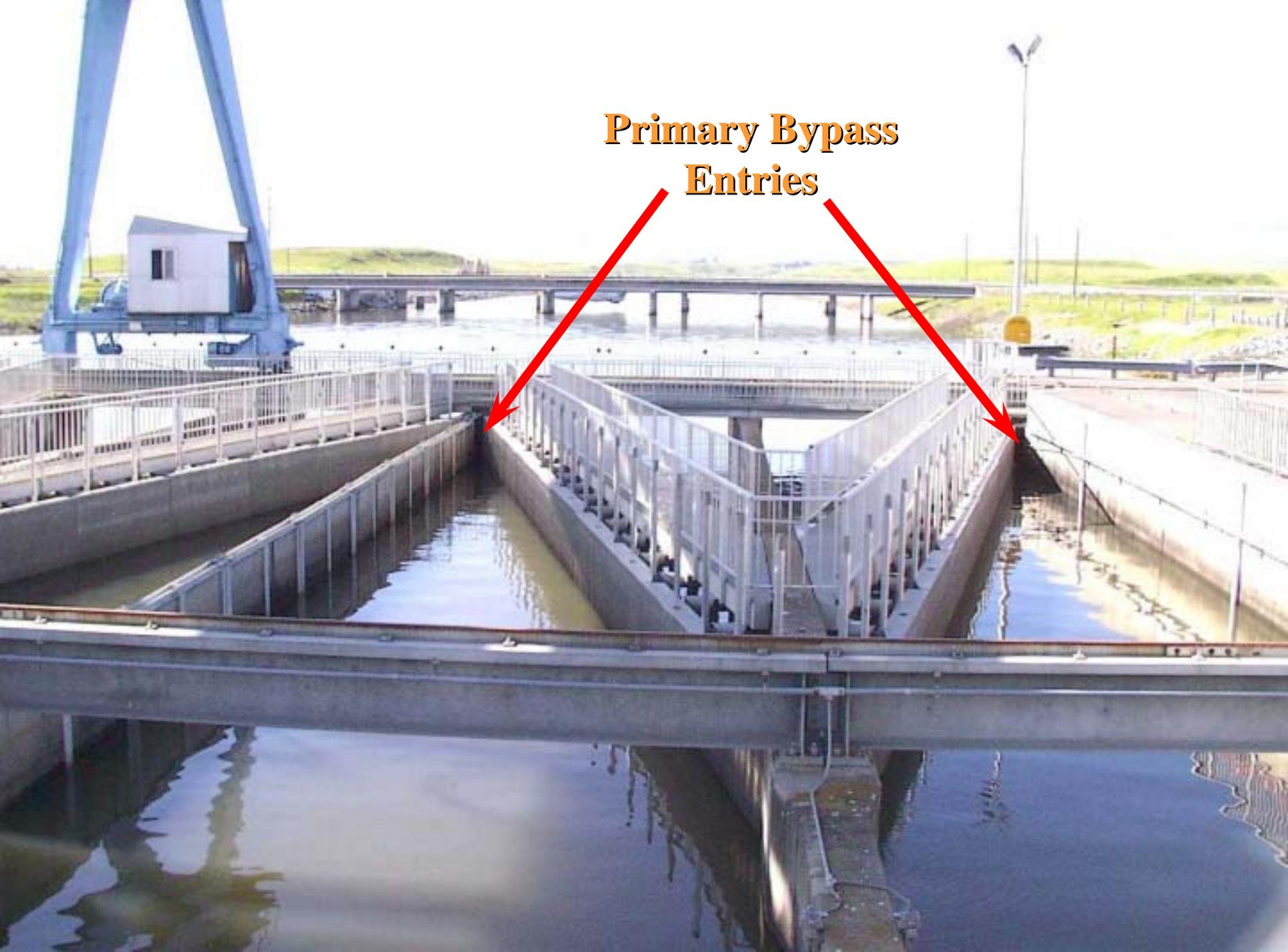
- **Fish surveys, population estimates**
  - Orsi 1967; Kano 1990; Morinaka c.1997
- **Tagging, hydro-acoustic, tracking studies**
  - Hall 1980; Reavis 1982; Bolster 1986;  
Collins *et al.* 1988; Gingras & McGee 1997
- **CCFB Sport fishing study**
  - Mecum 1980
- **Predator removal efforts (at Skinner)**
  - McEwan 1987a,b; 1988; Knoernschild 1991;  
Barrow 1991a-d; 1992
- **Direct observations (in CDFG documents)**
  - Raquel; McEwan; Collins; Odenweller

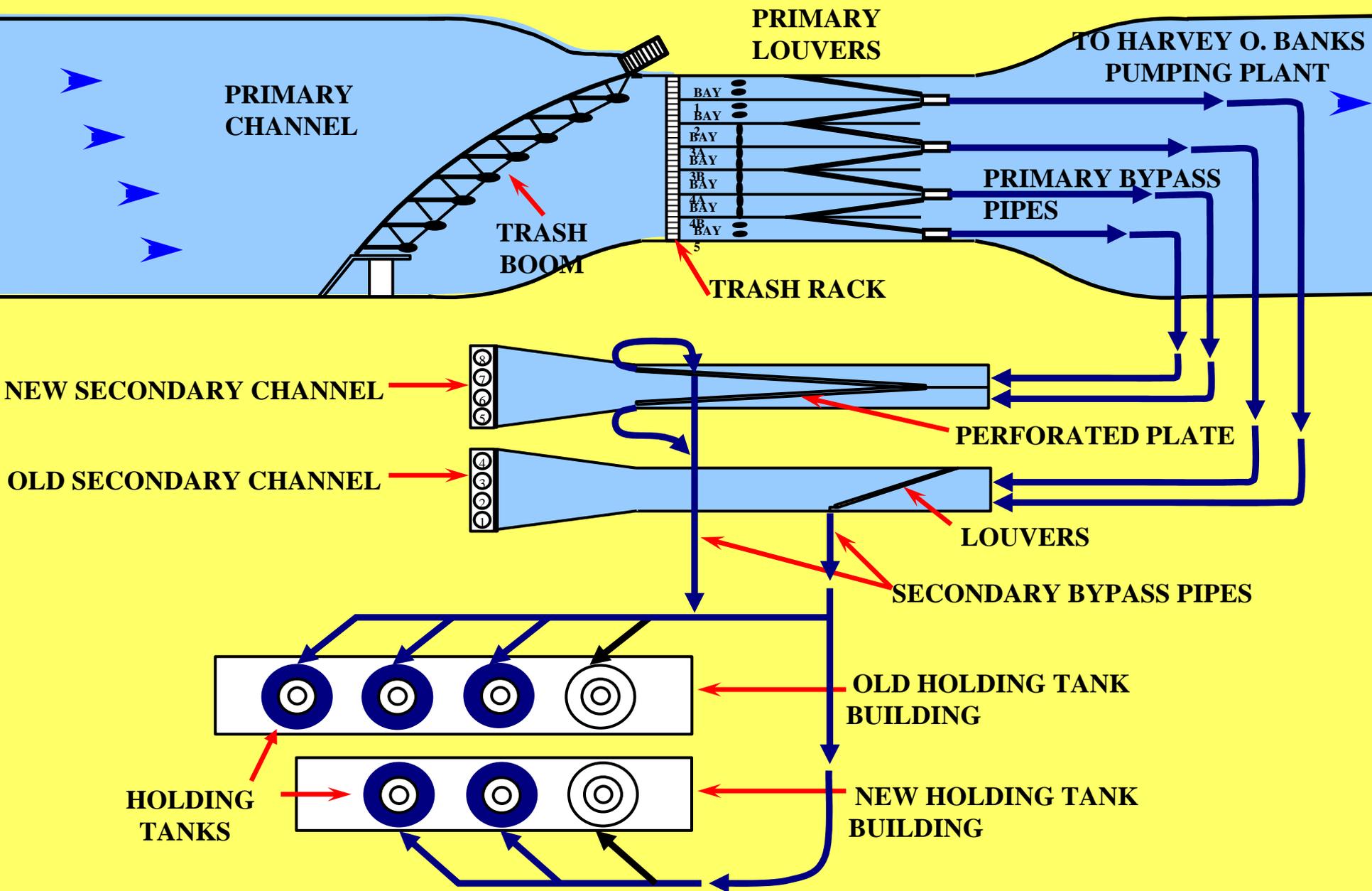
# MORE DETAIL

- **Skinner photos**
- **Skinner diagram**
- **Individual study results**



**Primary Bypass  
Entries**

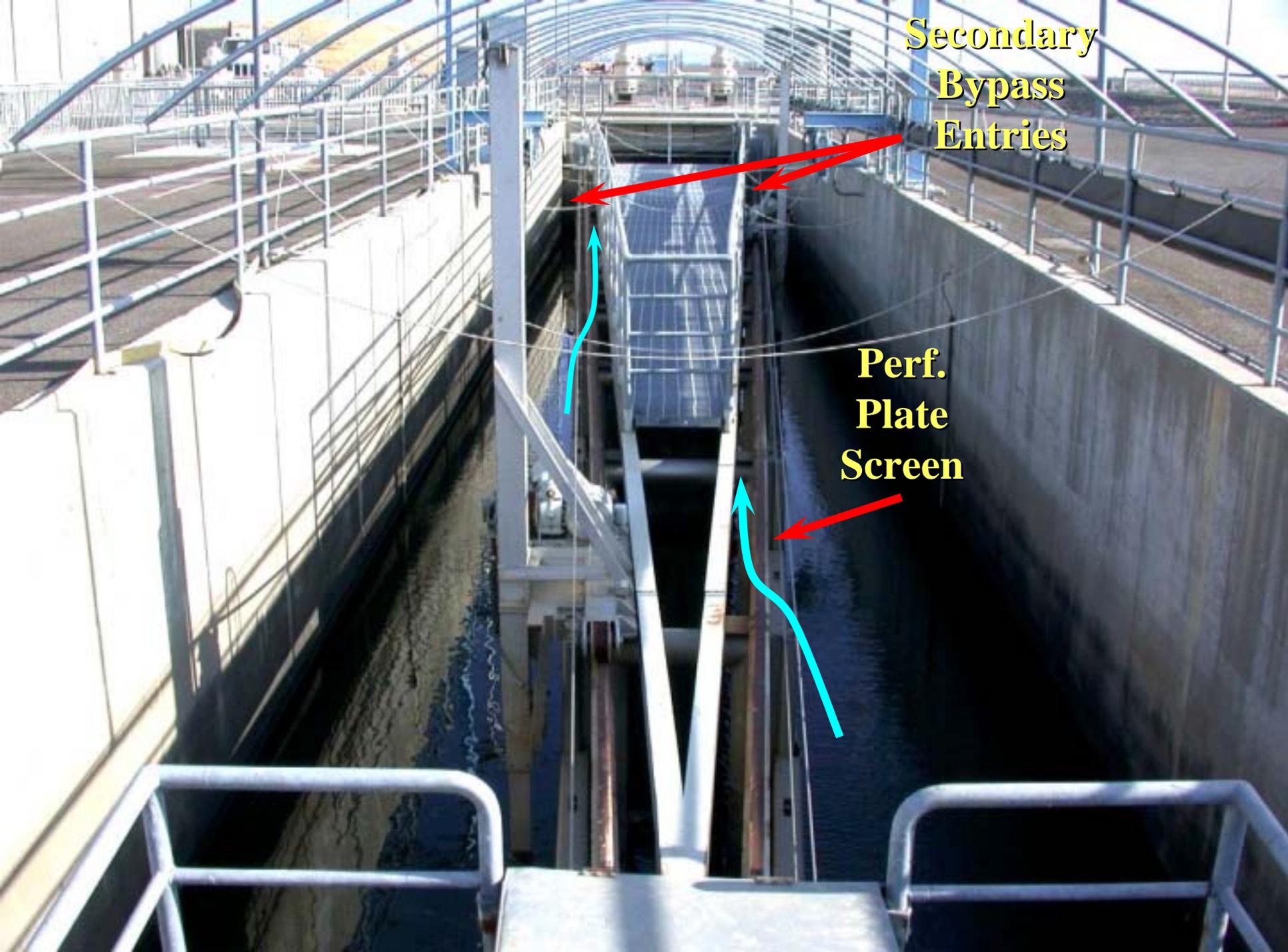




**Diagram of the John E. Skinner Delta Fish Protective Facility.**

**Secondary  
Bypass  
Entries**

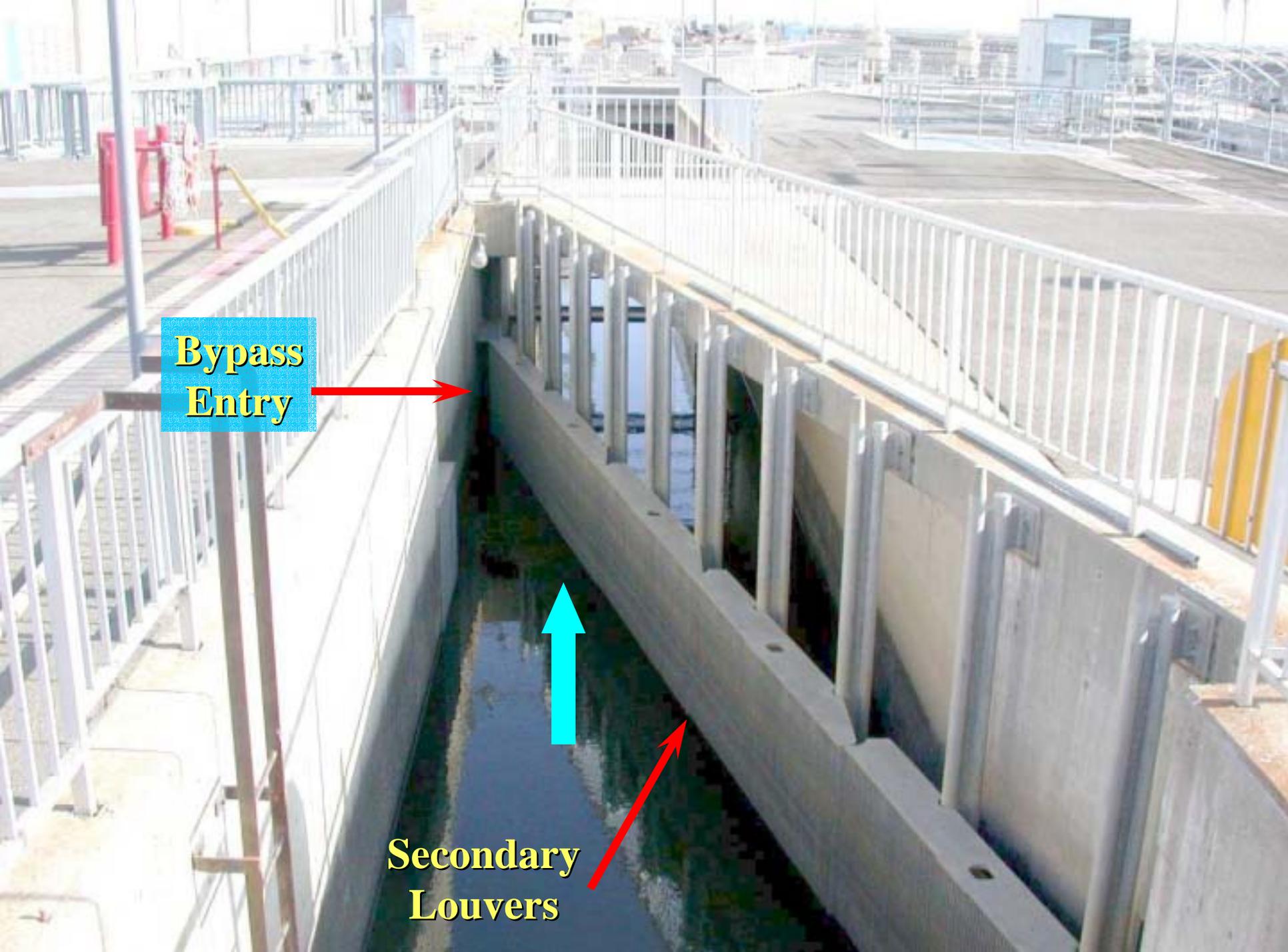
**Perf.  
Plate  
Screen**



**Bypass  
Entry**



**Secondary  
Louvers**



## Mid-Oct 1976 - Juvenile fall chinook (Schaffter 1978)

- **Radial gate night release: 6,825 (70-160 mm FL)**
- **No trash boom releases**
- **Assumed 67% louver efficiency (Heubach *et al.* 1973)**
- ***ONLY* off-peak pumping (night)**
- ⊕ **“Unaccounted” losses = 97%**
- ⊕ **97% of all recoveries in first 36 hrs**
- ⊕ **Water vel. @ gates est. at 10 fps + turbulence**
- ⊕ **Selective loss of smaller fish**
- ⊕ **Gillnet/beach seine efforts (limited):**
  - ⊕ **Striped bass @ CCFB inlet and outlet**

## Late Oct. 1978 - Juvenile late fall chinook (Hall 1980)

- Radial gate night release: 6,825 (60 - 150 mm FL)
- Outlet channel night release: 5,252
- Trash boom night release: 1,907
- Assumed 81% louver efficiency (Heubach *et al.* 1973)
- *Only* off-peak pumping (night)
- ⊕ Radial gate release to louver loss = 88%
- ⊕ Outlet channel release to louver loss = 64%
- ⊕ Trash boom release to louver loss = 15%
- ⊕ 69% of all recoveries within 2 days
- ⊕ Selective loss of smaller fish v. time ( $r^2=0.86-0.93$ )

## Late April 1984 - Juvenile fall chinook (Kano 1985a)

- **Rad. gate eve. (1830) release = 13,493 (FL  $\approx$  75 mm)**
- **Trash boom evening (1930) release = 2,900**
- **Trash boom night (2200) release = 2,953**
- **Assumed 74% louver efficiency (Heubach *et al.* 1973)**
- ✂ **Radial gate release to trash boom losses = 63.3%**
- ✂ **Trash boom release to louver losses = 9.8%**
- ✂ **Radial gate release to louver losses = 66.2%**
- ✂ **Radial gate release to salvage losses = 75.7%**
  - Difference attributed to spring v. fall
  - Difference attributed to lower predator population

## Mid-July 1984 - Juvenile striped bass (Kano 1985a)

- **Rad. gate day (1020) release : 13,710 (FL  $\approx$  52 mm)**
- **Trash boom morning (1015) release: 4,126**
- **Trash boom night (2130) release: 1,967**
- **Assumed 76% louver efficiency (Heubach *et al.* 1973)**
- **Off-peak Q = 2x on-peak Q**
- ✍ **Radial gate release to trash boom loss = 94%**
  - ✍ Correcting for louver losses
- ✍ **Trash boom to louver loss (combined) = 64%**
  - ✍ Correcting for louver losses

## Early April 1985 - Juvenile fall chinook (Kano 1985b)

- **Rad. gate eve. (1830) release: 11,606 (50-100 mm FL)**
- **Trash boom night (2345) release: 4,066**
- **Trash boom afternoon (1700) release: 1849**
- **Assumed 69% louver efficiency (Heubach *et al.* 1973)**
- ***ONLY* off-peak (night) pumping**
- ✂ **Radial gate release to trash boom loss = 75%**
- ✂ **Trash boom release to louver losses = 46 - 52%**
- ✂ **Peak radial gate release recoveries @ 2 days**
- ✂ **Striped bass CPUE 265% of previous year**
- ✂ **Survival proportional to export rate (weak)**

## Early August 1986 - Juvenile striped bass (Kano 1986)

- **Rad. gate day (1040) release: 18,486 (40-70 mm FL)**
- **Trash boom day (1100) release: 3,369**
- **Trash boom night (2145) release: 5,574**
- **Assumed 76% louver efficiency (Heubach *et al.* 1973)**
- ✂ **Radial gate release to trash boom loss = 70%**
- ✂ **Day trash boom to louver losses = 90%**
- ✂ **Night trash boom to louver loss = 60%**
- ✂ **Most radial gate release recoveries within 24 hrs.**

## Early May 1992 - Juvenile fall chinook (Bull 1992)

- Rad. gate night (2030) release: 21,894 (30-50 mm FL)
- Trash boom night (2130) release: 3,199
- Assumed 69% louver efficiency (Heubach *et al.* 1973)
- Pumping 6400 ~~↗~~ 375 ~~↗~~ 0 cfs 13 hrs after release
- ↗ Radial gate release to trash boom loss = 99%
- ↗ Trash boom release to louver losses = 71%
- ↗ Peak radial gate release recoveries @ 1 day
- ↗ High losses attributed to pumping curtailment

## Mid-Dec. 1992 - Juv. late fall chinook (Tillman 1993a)

- Radial gate night release: 10,729
- Trash boom night release: 1,782
- Assumed louver efficiency = 75% (Heubach *et al.* 1973)
- Delayed mortalities assessed
  - ✂ Radial gate release to trash boom loss = 78%
  - ✂ Trash boom release to louver losses = 25%
  - ✂ Mean length of recoveries increased over time
    - Attributed to selective predation on smaller fish
    - Similar results noted in previous studies
  - ✂ Most radial gate release recoveries within 26 hrs.

## Early Apr. 1993 - Juvenile fall chinook (Tillman 1993b)

- Radial gate night (2115) release: 10,332
  - Trash boom day (1045) release: 1,309
  - Trash boom night (2335) release: 1,209
  - Pumps @ 3,390 cfs
- ✍ Radial gate release to trash boom loss = 95%
- ✍ Trash boom release to louver losses = 75%
- ✍ Night trash boom survival 1.5 x day survival

## Late Nov. 1993 - Juv. late fall chinook (Bull 1994)

- Radial gate afternoon (1515) release: 4,246
- Radial gate *acclimated* (1530) release: 1,509
- Radial gate night (2350) release: 4,260
- Trash boom morning (1000) release: 469
- Trash boom afternoon (1434) release: 1849
- Trash boom night (2045) release: 233
- ✂ Radial gate day release to TB loss = 99.8%
- ✂ Radial gate night release to TB loss = 98.6%
- ✂ TB morning release to louver losses = 68%
- ✂ TB afternoon release to louver losses = 69%
- ✂ TB night release to louver losses = 53%